

5 We claim:

1. A mechanically fastened composite joint, comprising:

- (a) a substrate material;
- (b) a multi-layered composite mechanically joined to said substrate material by at least one fastener, said composite including:
 - 10 (i) a pair of resin-impregnated, fiber-containing layers, having a first toughness;
 - (ii) a fiber-containing core layer having a second, greater toughness than said pair of resin-impregnated fiber-containing layers, said fiber-containing core layer sandwiched between said pair of resin-impregnated, fiber-containing layers;

15 said composite joint having improved resistance to damage caused by externally applied forces.

2. The composite joint of claim 1 wherein said fiber-containing core layer comprises polymeric fibers and said pair of resin-impregnated, fiber containing layers comprise glass fibers.

3. The composite joint of claim 1 wherein at least one of said pair of resin-impregnated, fiber-containing layers comprises a fiber having a first tensile modulus and a first elongation at break, and said fiber-containing core layer comprises a fiber having a second, tensile modulus which is lower than said first tensile modulus, and a second elongation at break which is higher than said first elongation at break.

4. The composite joint of claim 1 wherein at least one of said pair of resin-impregnated fiber containing layers comprises a high tensile modulus fiber and said fiber-containing core layer comprises a roving, yarn, tow, poorly wetted or weakly bonded fibers.

- 5 5. The composite joint of claim 1 wherein said pair of resin-impregnated, fiber-containing layers are laminated to said fiber-containing core layer.
6. The composite joint of claim 5 further comprising a pair of polyolefin adhesive webs disposed between said fiber-containing core layer and each of said pair of resin-impregnated, fiber-containing layers for assisting in lamination.
- 10 7. The composite joint of claim 1 wherein said pair of resin-impregnated, fiber-containing layers and said fiber-containing core layer comprise two readily separable materials, amounting to at least 95 wt.% of said composite, for facilitating recyclability.
- 15 8. The composite joint of claim 7 wherein the fiber material of said pair of resin-impregnated, fiber-containing layers comprises a knit, woven or non-woven glass fabric having a basis weight of at least about 400 g/m², and the fiber material of the fiber-containing core layer comprises a woven or non-woven polymer fabric having a basis weight of at least 200 g/m².
- 20 9. An aircraft or motor vehicle body panel or door comprising the composite joint of claim 1.
10. The composite joint of claim 1 wherein said fiber-containing core layer comprises a thermoplastic yarn, roving, tow, woven or non-woven fabric, mat, scrim or web.
- 25 11. The composite joint of claim 10 wherein said fiber-containing core layer is impregnated with a resin.
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- 5 12. An energy absorbent laminate comprising:
- (a) a pair of composite layers containing a resin-impregnated glass fabric or mat
 having a first toughness;
- (b) a core layer laminated between said pair of composite layers having a second
 toughness which is greater than said first toughness, said core layer having a
10 greater elongation at break than said first layer;
- said core layer helping to at least distribute loads due to shear, cutting and impact forces
 exerted on said composite.
- 15 13. The composite joint of claim 12 wherein said pair of composite layers comprise a woven
 or non-woven fabric or mat made of high tensile modulus fiber, and said core layer comprises a
 lower tensile modulus fiber, or a poorly wetted or weakly bonded high tensile modulus fiber, a
 roving, yarn, woven fabric, non-woven fabric, tow or combination thereof.
- 20 14. The composite joint of claim 12 wherein said core layer comprises low modulus
 polymeric filaments and filaments of at least one high modulus reinforcing fiber selected from
 the group comprising: glass fiber, carbon fiber, boron fiber, aramid fiber or a combination
 thereof.
- 25 15. A method of mechanically fastening a composite joint, comprising:
- (a) providing a substrate material;
- (b) providing a multi-layered composite, including:
- (i) a pair of resin-impregnated, fiber-containing layers having a first
 toughness;
- (ii) a fiber-containing core layer having a second higher toughness sandwiched
30 between said pair of resin-impregnated, fiber-containing layers;

5 said substrate material and said multi-layered composite having aligned through-holes
therein for receiving at least one mechanical fastener;

- (c) disposing a mechanical fastener through said aligned through-holes of said multi-layered composite and said substrate material;
- (d) fastening said mechanical fastener to join said substrate material to said multi-layered composite whereby said fiber-containing core layer helps to at least
10 distribute shearout loads caused when said mechanical fastener is pulled in the direction of the plane of said multi-layered composite.

15 16. The method of claim 15 wherein said pair of resin-impregnated, fiber-containing layers are laminated to said fiber-containing core layer under heat, pressure, or both.

20 17. The method of claim 16 wherein said fiber-containing core layer comprises polymeric fibers and each of said pair of resin-impregnated, fiber-containing layers comprise glass fibers joined together in a roving, woven or non-woven fabric, yarn, tow, mat, scrim or combination thereof.

25 18. A multi-layered composite laminate, comprising:

- (a) a pair of resin-impregnated, fiber-containing layers having a first flexural modulus and a first toughness;
- (b) a fiber-containing core layer having a second, lower flexural modulus than said first flexural modulus and a second higher toughness than said first toughness, said fiber-containing core layer sandwiched between said pair of resin-impregnated, fiber-containing layers to form an integral composite;

- 5 (c) said integral composite having improved shearout resistance over a composite of
approximately the same thickness made entirely from said resin-impregnated,
fiber-containing layers having a first flexural modulus.
- 10 19. The composite of claim 18 wherein said pair of resin-impregnated, fiber-containing layers
and said fiber-containing core layer comprise substantially similar fiber compositions,
resin compositions, or both, for improved recyclability.
- 15 20. A multi-layered composite having improved energy absorbing properties comprising:
(a) a pair of resin-impregnated, fabric layers including high strength fibers;
(b) a core layer for absorbing energy directed to said composite by externally applied
forces, said core layer comprising polymeric fibers having greater toughness than
said high strength fibers, disposed in a roving, yarn, tow, knitted, woven or non-
woven fabric, scrim or combination thereof, said core layer laminated between
said pair of resin-impregnated glass fabric layers, under heat, pressure, or both, to
20 form an integral composite.
21. The multi-layered composite of claim 20, wherein said core layer is only partially melted
by said lamination.
- 25 22. A ballistic and explosion-resistant panel, comprising:
(a) a pair of resin impregnated, fiber-containing layers, having a first toughness;
(b) an aramid fiber-containing core layer having a second, greater toughness than said
first toughness, said core layer sandwiched between said pair of resin
impregnated, fiber-containing layers;
30 said multi-layered composite having improved resistance to ballistic impacts.

- 5 23. The panel of claim 21 wherein said aramid fiber-containing core layer comprises a woven or knit fabric.
24. The panel of claim 21 wherein said aramid fiber-containing core layer comprises a woven or non-woven fabric having a basis weight of at least 300-6,000 g/m².

PHI\878325.1